

evacuation continues until the aspirated liquid column passes the sample vessel 49 and reaches the jet ejector 22. At this point, because the jet ejector 22 is not capable of passing liquid nearly as rapidly as it passes gas, the liquid floods the jet ejector 22 and the rate of fluid passage therethrough decreases dramatically. By way of example, in a constructional model of the present invention, the jet ejector 22 is able to evacuate a 12 foot column of gas in about 2-3 seconds, but in the same period of time, it can pass a column of liquid only a few inches in length.

As the jet ejector 22 starts to evacuate liquid from the withdrawal conduit 20, the gas inflow at the gas bleed 30 causes the pressure in the withdrawal conduit 20 to increase. When this pressure exceeds the pressure in the reservoir 11, aspiration of liquid 12 will cease and a column of gas will be formed in the withdrawal conduit 20 behind the already-aspirated column of liquid. As the pressure in the withdrawal conduit 20 rises above the pressure of any residual gas in the sample vessel 49, liquid will flow into the sample vessel 49. This liquid flow into the sample vessel 49 will continue until pressure equilibrium is established between the withdrawal conduit 20 and the interior of the sample vessel 49, or until the jet ejector 22 exhausts the column of liquid in the withdrawal conduit 20. In this latter event, the column of gas behind the aspirated liquid column will reach the jet ejector 22, which will again evacuate it at a very rapid rate, whereupon the pressure in the withdrawal conduit 20 will drop and the withdrawal conduit 20 will again begin to be evacuated.

Preferably, the system 10 is set up so that pressure equilibrium between the interiors of the withdrawal conduit 20 and the sample vessel 49 will be established before the level of liquid in the sample vessel 49 reaches the tip of the upper end 47 of the cannula 46. Thus, if the jet ejector 22 exhausts the liquid in the withdrawal conduit 20 before the sample vessel 49 is removed, the collected liquid in the sample vessel 49 will not be drawn back into the withdrawal conduit 20.

After the sampled liquid has been collected in the sample vessel 49 in the manner described above, the sample vessel 49 is removed from the plug 45. Preferably, the system is designed so that at all times the pressure in the withdrawal conduit 20 is below the ambient pressure at the sampling station 16, so that if the sample vessel 49 is removed while liquid is still in the withdrawal conduit 20, liquid will not escape through the cannula 46.

It will be appreciated that when the column of liquid in the withdrawal conduit 20 has been exhausted by the jet ejector 22, and the column of gas therebehind is evacuated from the jet ejector 22, the aspiration of a new column of liquid 12 from the reservoir 11 will begin. Thus, it will be appreciated that alternating columns of liquid and gas will be formed in the withdrawal conduit 20, so that multiple samples of the liquid 12 can be taken. The system 10 may be designed so that a sample vessel 49 will be filled near the end of an aspirated liquid column, so that the vessel 49 may be removed and a new vessel 49 be installed in place to take a sample from the next aspirated column of liquid.

It will be appreciated that during the sampling operation, the sample vessel 49 and the plug 45 are handled by the remote manipulator 37, or by other isolated handling equipment such as a glove box or the like. Thus, it will be appreciated that the operating personnel in the control station 18 are at all times completely isolated

from the liquid 12 being sampled. Furthermore, it will be appreciated that the liquid 12 at no time comes in contact with any moving parts, operation of the system being controlled by the fixed jet ejector 22 and the gas bleed 30 and being completely fluid-operated.

When the last sample has been collected, the control valves 28 and 34 are closed. Thus, liquid in the withdrawal conduit 20 and the return conduit 24 will be permitted to drain by gravity back into the reservoir 11. It will also be seen that all liquid and gas which passes through the jet ejector 22 is returned via the return conduit 24 to the reservoir 11.

In a constructional model of the present invention, the withdrawal conduit 20 has approximately a $\frac{1}{2}$ inch inner diameter and the cannula 46 comprises a 20 gauge needle, (about $\frac{1}{2}$ millimeter inner diameter). This system is utilized to collect a 15 ml. sample in about one minute. Sample collection can require from 30 seconds to 4 minutes per sample depending on liquid viscosity, amount of foam, specific gravity, etc.

From the foregoing, it can be seen that there has been provided an improved method and apparatus for liquid sampling which is easily isolated, and in which no moving or high-maintenance parts come in contact with the sampled liquid.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Fluid-operated apparatus for withdrawing a sample of liquid from a reservoir comprising: a withdrawal conduit in fluid communication with reservoir, fluid-operated pump means communicating with said withdrawal conduit, sample collection means including a vessel disposable in fluid communication with said withdrawal conduit upstream of said pump means, said pump means reducing the pressure in said conduit for evacuating gas therefrom and from said sample collection vessel for inducing liquid flow through said conduit from the reservoir, and fluid-operated means responsive to the arrival of liquid from the reservoir at said pump means for raising the pressure in said withdrawal conduit at said sample collection vessel for causing liquid to flow into said vessel.

2. The apparatus of claim 1, wherein said pump means includes suction means.

3. The apparatus of claim 2, wherein said pump means comprises a jet ejector.

4. The apparatus of claim 1, and further including return conduit means providing communication between said pump means and the reservoir for cooperation with said withdrawal conduit to form a closed loop for returning excess liquid to the reservoir.

5. The apparatus of claim 1, wherein said responsive means comprises means for introducing gas to said withdrawal conduit upstream of said sample collection means.

6. The apparatus of claim 1, wherein said sample collection means is disposed at a sample collection station, and further including means isolating said sample collection station from the reservoir.

7. The apparatus of claim 6, and further including control means for controlling the operation of said pump means and said responsive means, and means isolating said control means from said sample collection station.

8. Fluid-operated apparatus for withdrawing a sample of liquid from a reservoir with no moving parts in contact with the liquid, said apparatus comprising: a